Retrograde mesenteric stenting during laparotomy for acute occlusive mesenteric ischemia

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Introduction: **Acute mesenteric ischemia (AMI) caused by arterial occlusive disease requires prompt diagnosis and revascularization to avoid the high mortality associated with this disease. In an attempt to minimize the magnitude of operation for arterial occlusive AMI, we have developed a new technique of endovascular recanalization and open retrograde stenting of the superior mesenteric artery (SMA) during laparotomy so that the bowel can also be assessed and resected if necessary.**

Methods: **All emergent mesenteric revascularizations for arterial occlusive AMI performed at Dartmouth-Hitchcock Medical Center from 2001 to 2005 (n = 13) were retrospectively reviewed. Outcomes were analyzed with respect to the method of revascularization and other perioperative variables. Restenosis was evaluated with duplex ultrasound imaging.**

Results: **Three different revascularization methods were used: surgical bypass (n = 5), antegrade percutaneous stenting (n = 2), and retrograde open mesenteric (SMA) stenting (ROMS, n = 6). Satisfactory revascularization was achieved in all cases and all methods. ROMS was successfully accomplished in three of six patients after antegrade attempts to cross the SMA from the arm were unsuccessful. At 17%, the ROMS group had the lowest hospital mortality compared with bypass at 80% (*P* = .08) and percutaneous stent at 100% (*P* = .11). All five of the surviving patients treated with ROMS were discharged to home after a mean hospital stay of 20 days (range, 6 to 38 days). During a mean follow-up of 13 ± 7 months, three patients died of unrelated causes, of which two were being followed with asymptomatic recurrent SMA stenosis detected by duplex scan. The two surviving patients are alive and well, but one has required percutaneous SMA stenting of a progressive asymptomatic restenosis.**

Conclusion: **Retrograde open SMA stenting during laparotomy for AMI has a high technical success rate and provides an attractive alternative to surgical bypass in these often critically ill patients. Because it is combined with open laparotomy, it honors the essential surgical principles of evaluating and resecting nonviable bowel. Restenosis rates appear to be high, so that patients must be followed closely. Further study and development of this new hybrid technique is warranted. (J Vasc Surg 2007;45:269-75.)**

Acute mesenteric ischemia (AMI) caused by atherosclerotic occlusive disease has traditionally been treated with emergent operative bypass, often combined with segmental resection of nonviable small bowel. The reported mortality rate for these patients varies from 75% to 100%.[1,2] Endovascular treatment for chronic mesenteric ischemia has been well described for subacute presentations, especially in patients at high operative risk or as a bridge to a more elective surgical bypass after the acute illness has resolved.[1,3-7]

Endovascular treatment has not, however, generally been applied to patients with AMI who need emergent revascularization and potential resection of nonviable bowel. This is because such a percutaneous procedure does not allow for an assessment of bowel viability, requires advanced endovascular skills, and even in the most experienced hands, can take substantial time that might delay revascularization.

Retrograde open mesenteric stenting (ROMS) is a hybrid technique, similar to that described by Milner et al[8] in a 2004 case report, that combines open surgical and endovascular approaches. Previously unaware of this report, we developed our variation of this technique contemporaneously and first performed it in 2002.

In this approach, the SMA is exposed at the base of the transverse mesocolon for retrograde cannulation after local patch angioplasty at the intended puncture site. Like traditional surgical bypass, this approach allows for an accurate assessment and treatment of any nonviable bowel during laparotomy. At the same time, stenting of the superior mesenteric artery (SMA) is performed to revascularize the viscera. Cannulation through the infracolic SMA offers the potential advantage of a more direct approach to lesions that might otherwise require arm or prolonged femoral access. This report presents our early experience with this approach in a select group of patients with occlusive AMI who required emergent revascularization.

PATIENTS AND METHODS

We reviewed all patients who underwent emergent mesenteric revascularization for arterial occlusive AMI from 2001 to 2005. Patients with embolic mesenteric occlusions were excluded, and only the subset of patients

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Table I. Preoperative patient variables

Patient	*Year*	*Age*	*Gender*	*Time to OR (hours)*	*WBC (1000s)*	*Acidosis*	*Imaging*
Surgical bypass							
JC	2003	67	M	24	17.2	Y	Angio
EO	2001	86	F	12	3.7	Y	MRA
GJ	2003	60	M	96	3.8	Y	CT
MM	2002	39	F	12	17.1	N	CT
LC	2002	66	F	30	10.5	Y	Angio, CT
Percutaneous antegrade stent							
DK	2002	71	F	48	31	N	CT
EW	2001	64	F	24	19.5	Y	Plain x-ray
Retrograde SMA stent							
RS	2002	60	M	48	10.4	Y	Angio, CT
HE	2005	66	F	24	21.2	Y	Duplex
VG	2004	67	F	3	1.1	N	Angio
IM	2004	68	F	48	14.9	Y	CT
LW	2004	62	F	36	28.4	N	CT
RG	2005	52	M	72	32	N	CT

WBC, White blood cells; *OR,* operation; *MRA,* magnetic resonance angiography; *CT,* computed tomography; *SMA,* superior mesenteric artery.

with acute presentations of thrombo-occlusive mesenteric ischemia that required emergent treatment was analyzed. A retrospective review was then performed of 14 patients who met these criteria. One of these patients was excluded from analysis because the revascularization was abandoned owing to total necrosis of the small bowel found at laparotomy. Of the 13 remaining patients, five were treated with a traditional open surgical bypass, two were treated with antegrade percutaneous SMA stenting, and the remaining six were treated with ROMS.

Patient selection into the different treatment groups in this small series was essentially chronologic and mirrors the evolution of our endovascular experience with mesenteric interventions. The first five patients were treated with bypass because this predated our experience even with elective mesenteric stenting. As our experience with percutaneous mesenteric stents increased, we began to consider this application for more urgent indications.

Percutaneous attempts at recanalization of the occluded SMA proved to be very time consuming, and in this patient population, the need for bowel exploration could not be avoided. As such, the two patients who were treated with antegrade percutaneous SMA stenting represent a transition to the more recent development of the ROMS technique. Emergent percutaneous revascularization in our practice has been replaced by ROMS when the abdomen must be explored to determine bowel viability. The first retrograde mesenteric stent implantations were performed in patients with peritoneal soilage and no apparent saphenous conduit or with calcified, infrarenal inflow vessels that could not be clamped for retrograde bypass. Subsequently, as a result of good outcomes, this has become our preferred approach.

Surviving patients were followed-up clinically and underwent periodic mesenteric duplex evaluation. The same duplex protocol used for the identification of primary SMA stenosis was used to detect recurrent stenoses; this has been previously published.[9] Briefly, our diagnostic criteria for a 50% SMA stenosis include a fasting peak systolic velocity (PSV) $>$300 cm/s and an end-diastolic velocity (EDV) $>$45 cm/s. Repeat angiography was performed in medically suitable patients at the surgeon's discretion when a restenosis was identified by duplex or when recurrent symptoms prompted such intervention.

Statistical analysis was limited by the small numbers of patients. Fisher's exact testing was used where appropriate to determine significance between proportions, and analysis of variance was used for continuous variables.

Retrograde open mesenteric stent technique. A patient with suspected AMI on clinical grounds or from preoperative imaging (Table I) is brought directly to the operating room while resuscitation is ongoing. With the patient supine, the left arm is abducted and also undergoes sterile preparation in the event that brachial access is required. Depending on the degree of preoperative evaluation, a diagnostic arteriogram may be obtained initially through a brachial or femoral approach. Once the diagnosis is confirmed, the abdomen is explored by using a midline laparotomy.

The infracolic SMA is exposed and controlled inferior to the transverse colon mesentery. At this point, the patient is fully heparinized, and the activated clotting time is maintained at $>$300 seconds until the revascularization is complete. The artery is incised longitudinally, and a local thromboendarterectomy is performed if necessary. A patch angioplasty of the SMA is performed to facilitate the next portion of the procedure. We most commonly use a bovine pericardial patch (Vascu-Guard, Synovis, St Paul, MN), but a saphenous vein patch can also be used if the peritoneal soilage is significant. The patch can be further protected by closure of the peritoneum over the site of the SMA exploration.

A 6F, 35-cm-long flexible sheath (Arrow International Inc, Reading, PA) is then placed into the SMA in retro-

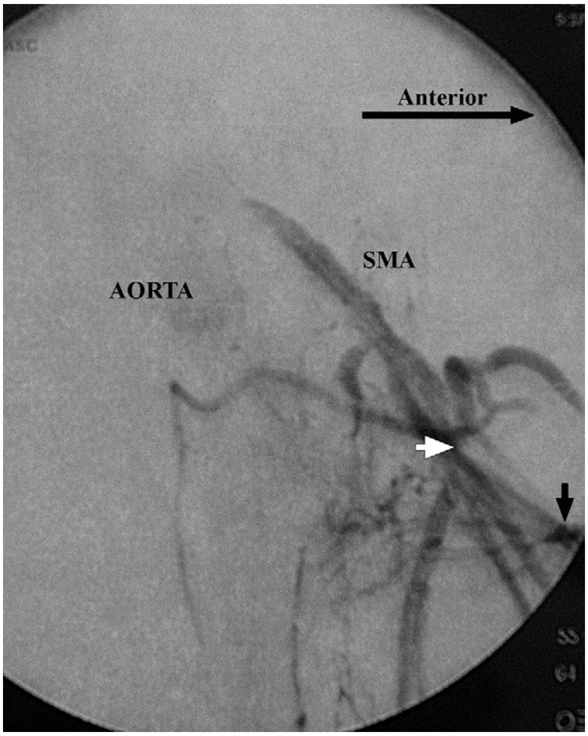

Fig 1. Retrograde superior mesenteric artery *(SMA)* injection. Note the proximity of the sheath's point of entry *(black arrow)* and of the sheath's tip *(white arrow)* to the proximal SMA occlusion. There is no reflux of contrast into the aorta.

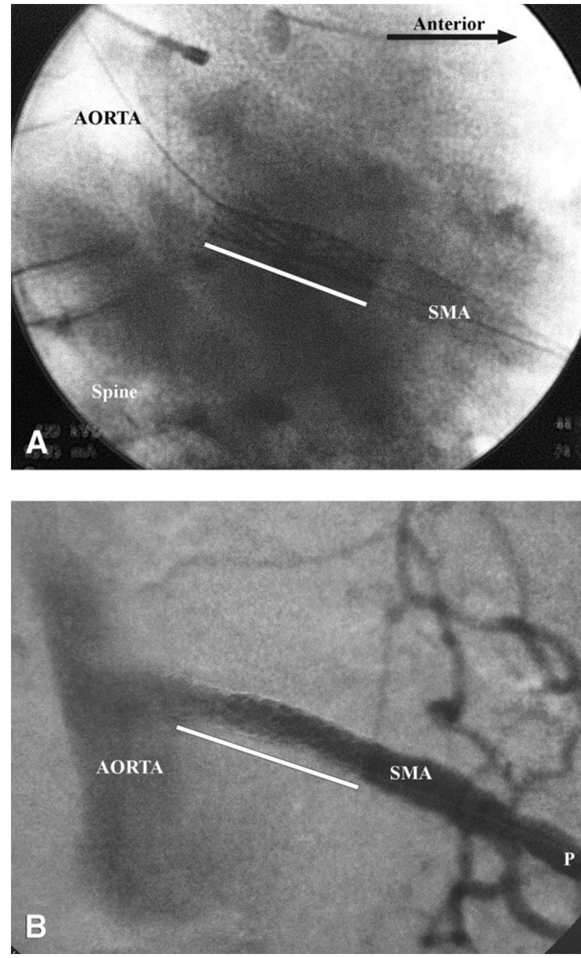

Fig 2. A, Intraoperative lateral fluoroscopic image shows two stents (underscored by a *white line*) deployed in the superior mesenteric artery *(SMA)* origin with the 0.018-inch wire still in place. Note the lumbar vertebral bodies to the left. **B,** Completion retrograde arteriogram shows free reflux of contrast into the aorta and no residual angiographic stenosis; *P* denotes the approximate location of the SMA patch angioplasty.

grade fashion through the distal end of the patch. We prefer to place the working sheath through the patch rather than through an open arteriotomy to facilitate angiographic evaluation of the distal mesenteric arcade before and immediately after restoration of antegrade flow. A purse string suture can be placed in the patch before its puncture to facilitate sheath removal without having to reclamp the SMA. The longer-length working sheath here is important so that during fluoroscopy the surgeon can work comfortably, out of the wound and away from the image intensifier.

Once the sheath is in place, all metallic abdominal retractors are removed and the surgeon performs hand-injected retrograde, lateral angiography (Fig 1). This is used as a roadmap to cross the SMA stenosis or occlusion. A simultaneous flush aortography using a femoral or brachial catheter can also be done to provide a re-entry target and to confirm anatomic landmarks.

A 0.035-inch glidewire (Terumo, Somerset, NJ) is typically used to cross the lesion luminally or subadventitially if necessary. The 0.035-inch glidewire is then catheter exchanged in favor of a lower-profile 0.018-inch or 0.014-inch platform. The lesion usually requires predilation with a 2-mm or 3-mm angioplasty balloon and then is retrograde stented with a 5-mm to 7-mm low-profile balloon-expandable stent (Fig 2), with the proximal-most stent allowed to protrude 1 mm to 2 mm into the aortic lumen. Frequently, more than one stent is required to cover these lesions, which are typically 2 cm to 3 cm in length (Fig 2, *A*).

Before the sheath is removed, completion arteriography is performed in both anteroposterior and lateral projections (Fig 2, *B*), and pressure measurements are performed across the stented region to confirm that there is no residual pressure gradient. An anteroposterior arteriography can also be performed to see the full mesenteric arcade and evaluate collateral supply to the foregut. The sheath puncture site in the patch is repaired. Any perforated or severely necrotic bowel that is likely to perforate is expeditiously resected with a gastrointestinal stapler, but final assessment of bowel viability and advisability of reanastomosis maybe delayed until a second-look procedure is performed in 24 to 48 hours.

Table II. Perioperative results

Patient	*Bowel necrosis*	*Revascularization*	*Duration (min)*	*Outcome (POD)*	*Adjunctive procedures*
Surgical bypass					
		Conduit/inflow source			
JC	No	PTFE/Iliac	584	Death (59)	Second look POD 3
EO	Yes	Vein/supraceliac Aorta	320	Death (3)	Resection ischemic ileum, second look POD 1
GJ	Yes	Vein/iliac	283	Death (13)	Second look POD 1, resection necrotic ileum
MM	Yes	PTFE/supraceliac Aorta	289	Home (40)	Failed perc stent attempt. Subtotal colectomy, cholecystectomy, resection ileum, second look POD 2
LC	Yes	Vein/iliac	186	Death (2)	Acute thrombosis of SMA stent, resection of ileum. Second look POD 2, graft thrombosis
Percutaneous antegrade stent					
		No. stents/diameter			
DK	Yes	2/5 mm	283	Death (6)	Subtotal colectomy
EW	Yes	3/6 mm	375	Death (1)	Ileum resection. Second look. POD 1, small bowel appeared ischemic? Low flow.
Retrograde SMA stent					
		No. stents/diameter			
RS	Yes	2/6	273	Death (25)	Failed perc stent attempt, second look POD 1; R hemicolectomy, developed R leg ischemia; AKA.
HE	No	2/7 mm	260	Home (27)	Previous celiac stent; failed previous SMA stent for CMI. Second look POD 3
VG	No	2/6 mm	194	Home (38)	Failed perc stent attempt by interventional radiology immediately before to exploration.
IM	Yes	2/7 mm	348	Home (22)	Failed perc stent attempt, Small bowel resection
LW	No	2/6 mm	315	Home (6)	Failed perc stent attempt
RG	Yes	1/7 mm	298	Home (8)	Subtotal colectomy

POD, Postoperative day; *PTFE,* polytetrafluoroethylene; *SMA,* superior mesenteric artery; *AKA,* above knee amputation; *CMI,* chronic mesenteric ischemia.

RESULTS

Patient and preoperative variables are recorded in Table I. The amount of time between the onset of constant abdominal pain or tenderness was estimated from the medical record to determine if an inordinate delay in diagnosis or treatment occurred in any patient. The average preoperative time delay to operation for the bypass, percutaneous stent, and ROMS groups was 35, 36, and 38 hours, respectively. Total duration of the operative procedure including adjunctive bowel resection averaged a mean $\pm$ SD of 332 $\pm$ 67 minutes for bypass, 329 $\pm$ 46 for percutaneous stent, and 281 $\pm$ 21 minutes for ROMS ($P = .45$; Table II).

Preoperative white blood cell counts were either abnormally high (>10,000) or low (<4000) in all patients (Table I). Acidosis was defined as pH <7.3, serum bicarbonate <18 mmol/L or elevated serum L-lactate levels and was not different between groups ($P \geq .54$).

Preoperative imaging consisted of computed tomography (CT) in 8, angiography separate from the index revascularization procedure in 4, magnetic resonance angiography (MRA) in 1, duplex ultrasound imaging in 1, and plain abdominal radiographs in 1. Among the 8 patients who underwent preoperative CT scanning, the study was considered diagnostic of AMI in four patients and strongly supportive of the diagnosis in the remaining four.

Surgical bypasses were performed to the SMA only and satisfactorily revascularized the intestine in all five cases. Two were preformed in antegrade fashion from the supraceliac aorta: one because of extreme calcification of the iliacs and infrarenal aorta that rendered those inflow arteries unclampable, and the other because of aneurysmal infrarenal aorta and iliac segments. Three bypasses were oriented in retrograde fashion using an iliac artery as the inflow source. One donor iliac artery required endarterectomy and another required repair of a clamp injury before construction of the bypass.

Vein grafts, when used (Table II), were the great (n = 2) or anterior saphenous (n = 1) vein. The saphenous was the intended conduit for a fourth patient but was found to be inadequate for bypass. A kinked vein graft resulted in one early graft failure in the retrograde bypass group, and this patient did not survive because of complications of bowel infarction associated with the graft occlusion.

There were no prosthetic graft infections despite the eventual requirement for bowel resection owing to necrosis in both patients in whom these grafts were used. Two patients in the bypass group required bowel resection at the initial operation, and all patients required a subsequent second-look operative reassessment and eventual resection of nonviable bowel. In-hospital mortality for this group was 80%. Three of four deaths were associated with multisystem organ failure as a consequence of the AMI, and the fourth death was due to bowel necrosis after bypass graft occlusion.

Two patients had successful percutaneous SMA stenting: one to treat a severe stenosis and the other to recanalize an occluded SMA (Table II). The patient with the SMA occlusion then required open SMA endarterectomy with

Table III. Follow-up of surviving retrograde stent patients

Patient	*Follow-up (months)*	*Restenosis*	*Symptomatic*	*PSV/EDV (cm/sec)*	*Secondary procedure*	*Comment*
HE	10	Yes	No	321/67	Restent, 4.2 mo	Alive, asymptomatic
VG	20.2	Yes	No	399/159	None	Died of acute myelogenous leukemia, 20 mo post-op
IM	1	NA	NA	NA	—	Died of presumed AAA rupture, 1 mo post-op
LW	16.5	Yes	No	409/103	None	Died of unknown cause, 16 mo post-op
RG	4.5	No	No	195/32	Angio only, 4.5 mo	Alive, asymptomatic

PSV, Peak systolic velocity; *EDV,* end-diastolic velocity; *NA,* not applicable.

patch angioplasty of the distal SMA beyond the stent because of diffuse occlusive disease. Stent diameters are listed in Table II. The initial plan to evaluate the intestine laparoscopically in these two percutaneously treated patients was abandoned in favor of operative exploration in one patient because of this need to endarterectomize the distal SMA and in the other because of inadequate visualization with the laparoscope. Both patients required bowel resection after the revascularization was complete. Both patients died within a week of their initial operation, one from multiple system organ failure and the second from bowel necrosis that occurred after stent thrombosis.

ROMS was performed as described in six patients with SMA occlusions and was technically successful in all patients (Table II). In five, a prior attempt at antegrade SMA stenting through a brachial approach was unsuccessful (3 during this index procedure, and 2 previously during a separate attempt at SMA stenting). Two retrograde stents, each about 18 or 19 mm long, were required for each SMA and were either 6 or 7 mm in diameter, for a mean expanded diameter of 6.4 mm. The incidence of bowel necrosis in this retrograde stent group was 50%.

Although we maintain a low threshold for second-look operations, only two patients required a second-look laparotomy to evaluate bowel viability. The need for a second look is assessed daily by both general and vascular surgery services and is strongly influenced by the patient's overall condition as well as specific variables such as acidosis, white blood cell count, return of bowel function, and abdominal exam.

This apparently reduced incidence of bowel infarction did not, however, reach statistical significance when compared with the other groups ($P = .18$ vs open revascularization; $P = .46$ vs percutaneous group). The cause of the single death in this group was multiple system organ failure. Despite the small numbers, in-hospital mortality was significantly lower in this ROMS group at 17% compared with the 80% in the bypass group ($P = .08$) and 100% ($P = .11$) in the percutaneous stent group.

Five of six patients in the retrograde stent group survived and were discharged to home (Table III) after a mean hospital stay of 20 days (range, 6 to 38 days). One of those five died suddenly and unexpectedly at home 1 month after her retrograde stent procedure. An autopsy was not performed, but this patient had a known 7-cm thoracoabdominal aneurysm, and given the rapidity of her death, this was presumed to be the actual cause.

The four remaining retrograde stent patients have been followed-up for a mean of 13 ± 7 months (Table III), and two have subsequently died. One patient (VG) was followed-up closely with a recurrent, asymptomatic stenosis until her death from acute myelogenous leukemia 20 months after her mesenteric revascularization. Another late death occurred at home in a very debilitated patient (LW) 16 months' postoperatively. She had no abdominal symptoms, but a variety of other medical comorbidities and was being followed up by duplex imaging for a progressive, severe in-stent restenosis. No autopsy was performed.

The two remaining patients are asymptomatic and both have had repeat outpatient arteriograms approximately 4 months postoperatively. One (HE) was found to have a recurrent, asymptomatic stenosis on duplex that was successfully treated with additional stents placed percutaneously. The restenosis has not recurred in the interval 6 months. The second patient (RG) underwent selective mesenteric arteriography for screening as part of another peripheral percutaneous intervention for claudication and there is no recurrent mesenteric stenosis.

DISCUSSION

Acute thrombo-occlusive mesenteric ischemia requires prompt diagnosis to avoid bowel necrosis and the incumbent morbidity and mortality. Confirmatory diagnosis with conventional arteriography or, increasingly, with high resolution CT angiography (CTA)[10-13] performed early in the patient's presentation is critical to reduce the incidence of ischemic bowel.

In the emergent setting, retrograde bypass to the SMA with vein or synthetic conduit is arguably the most commonly performed procedure. Antegrade bypass from the supraceliac aorta to one or both mesenteric vessels is ideally reserved for elective bypass in more stable patients because it is more physiologically stressful.[14] A less invasive option for SMA revascularization in these critically ill patients is theoretically appealing. Whichever revascularization strategy is followed, however, the general surgical principles of thorough abdominal exploration, sepsis control, and a low threshold for second-look operations must be honored to increase chances for a favorable outcome.

The ROMS technique allows confirmatory angiography to be followed immediately by definitive revascularization in the same operative setting. We believe that ROMS, in carefully selected patients, is a promising new hybrid procedure that provides an efficient, less-invasive mesenteric revascularization while not compromising important general surgical principles. As was seen in this small series, donor vessel problems, such as abdominal aortic aneurysm or severe aortic or iliac calcification, can complicate an operative bypass or potentially force the need for the more complex antegrade bypass. ROMS avoids aortic clamping as well as potential difficulty with aortic or iliac artery quality.

ROMS can also avoid the issue of prosthetic conduit in a field that is often contaminated by using only a small bovine pericardial patch or a vein patch. We have found that patch angioplasty of the SMA and puncture of the patch, rather than direct SMA puncture, avoids inadvertent artery injury and assures lack of disease at the puncture site by allowing local endarterectomy if needed. Endarterectomy was required in only one patient in the ROMS group because of a focal plaque that involved the anterior wall of the artery that could not be treated with patch angioplasty alone. Thrombus volume was usually small and was usually limited to the retropancreatic portion of the SMA, above any of the proximal SMA branches. Fogarty embolectomy should be considered, but was not usually required of the distal SMA.

In addition, placement of the working sheath through the SMA patch is secure while still allowing for some runoff through the distal mesenteric arcade. This greatly facilitates angiography and allows pressure measurements across the SMA stents. If a pursestring suture is placed before patch puncture, the sheath can be removed without reclamping the diseased SMA in proximity to the newly placed stents and with no further ischemia time.

Because of the multiple adjunctive procedures of bowel resection, cholecystectomy, and operative diagnostic arteriography, it was not possible to accurately compare the time required for revascularization in these small subgroups. The mean operative time in the ROMS group would likely have been shorter were it not for a failed attempt at percutaneous stent placement before retrograde placement in three of six patients (Table II). We no longer make any percutaneous attempt in patients who present with AMI.

It is our impression that ROMS is as fast or faster than an uncomplicated retrograde bypass with synthetic conduit. It is likely faster than a vein bypass because it eliminates the search for, harvest of, and preparation of conduit. In at least one patient in the bypass group, vein harvest was attempted before it was judged to be inadequate, which required the use of prosthetic conduit and further delayed revascularization. ROMS also avoids the potential kinking problems of vein bypass in a retrograde fashion to the SMA, which we experienced in one of our patients.

Percutaneous endovascular treatment of acute mesenteric occlusions combined with laparoscopy to assess bowel viability has been reported.[15,16] Diagnostic laparoscopy for this indication has not been widely accepted[17] because it may miss areas of nonviable bowel. Furthermore, the technical success rate with percutaneous recanalization of occluded mesenteric arteries is lower than the 100% technical success rate reported here in our early experience with ROMS. In fact, five of the six patients successfully treated by ROMS underwent previous unsuccessful attempts at antegrade treatment of their SMA occlusion (Table II). Three of these previous attempts were performed in the operating room immediately before the ROMS procedure and additionally may have caused some overestimation of the operative time required for ROMS.

We believe that this higher technical success rate is due to superior pushability and torquability achieved by direct SMA access close to the point of obstruction. In addition, we have had no difficulty with re-entry into the abdominal aorta when subintimal passage of the wire occurs. For longer SMA lesions, ROMS also allows local endarterectomy to increase flow distally. Retrograde stenting also allows for protection against distal embolization, both atheroemboli and thromboemboli, which may occur during attempts at crossing the occlusion antegrade. In our practice, we now reserve percutaneous mesenteric stenting for patients with chronic or subacute presentations who do not require a detailed assessment of bowel viability.

Although we have only compared a small number of patients, we observed a strong trend towards a lower in-hospital mortality rate in the ROMS group. An equally efficacious procedure with less associated physiologic stress is appealing, but we cannot be certain from this initial experience that improved survival is a result of this technique. The improved survival may be the result of earlier diagnosis and better preoperative imaging with multidetector CTA. The difference in time to operation was not different between the groups, but there was a trend toward less frequent bowel resection in the ROMS group. This may be the better surrogate marker for delay in diagnosis and explain the results in such a small, highly selected group of patients. The retrospective, highly selected nature of this small case series constitutes the main weakness of such a report. Larger numbers of patients, followed up prospectively, would be necessary to determine the potential impact of this technique on morbidity and mortality rates.

The main limitation with mesenteric stenting in general, which we and others have reported,[4,18-20] is the high rate of recurrent stenosis. Restenosis rates may be even higher in these patients because of the longer lesion length associated with complete occlusions. Frequent duplex surveillance is required to judge the need for reintervention. Recurrent stenosis seems to happen relatively early after mesenteric stenting,[4] so we recommend surveillance within the first month and every 3 months thereafter.

Most patients can be retreated with a percutaneous approach as outpatients. Many of these patients remain poor operative candidates and have limited life expectancies because of other comorbidites,[14] and in this situation, even repeated SMA dilatations are a viable, safe option. For patients who make a good recovery and are nutritionally sound, ROMS, like percutaneous stenting for chronic mesenteric ischemia, may serve as a bridge to a more durable operative bypass.[5] In the near future however, balloon-expandable stent grafts or large-diameter drug-coated stents may be useful to reduce the problem of restenosis.

CONCLUSION

We believe that retrograde open mesenteric stenting offers an efficient alternative for emergent superior mesenteric artery revascularization in cases of arterial occlusive acute mesenteric ischemia. It avoids many of the problems associated with emergent mesenteric bypass. At the same time, because it is combined with open laparotomy, it incorporates the essential surgical principles of sepsis control. Like other forms of mesenteric stenting, however, it seems to have a high rate of restenosis that requires close duplex surveillance to determine the need for secondary intervention. Further study and development of this new hybrid technique is warranted.

AUTHOR CONTRIBUTIONS

Conception and design: MW, RP, BN, JC
Analysis and interpretation: MW, JC
Data collection: MW
Writing the article: MW
Critical revision of the article: MW, JC, RP, BN
Final approval of the article: MW, JC, RP, BN
Statistical analysis: MW, JC
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Overall responsibility: MW

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